

CLAIMS

## WHAT IS CLAIMED IS:

- 1       1. An apparatus for preparing a substrate, the apparatus comprising:  
2           an electromagnetic radiation source for generating an active zone, wherein said  
3           electromagnetic radiation comprises radiation in the far ultra-violet region and wherein  
4           said electromagnetic radiation is directed to impinge on the substrate exposing a surface  
5           of the substrate to the active zone whereby the substrate is modified for adhering a  
6           material onto the surface of said substrate by exposure to said active zone, and  
7           wherein the apparatus operates at substantially ambient pressure.
- 1       2. The apparatus of claim 1, wherein said electromagnetic radiation further comprises infra-  
2           red radiation.
- 1       3. The apparatus of claim 1, wherein said electromagnetic radiation comprises radiation  
2           having a wave length in the range of about 150 nanometers to about 300 nanometers.
- 1       4. The apparatus of claim 1, wherein said electromagnetic radiation comprises radiation  
2           having a wave length in the range of about 150 nanometers to about 250 nanometers.
- 1       5. The apparatus of claim 1, wherein the intensity of said electromagnetic radiation ranges  
2           from about 2.0 joules per square centimeter to about 5,000 joules per square centimeter.
- 1       6. The apparatus of claim 1, wherein the intensity of said electromagnetic radiation ranges  
2           from about 10 joules per square centimeter to about 1000 joules per square centimeter.
- 1       7. The apparatus of claim 1, wherein the electromagnetic radiation source is stationary.
- 1       8. The apparatus of claim 1, further comprising:  
2           a conveyor system for conveying the substrate through said active zone whereby the  
3           substrate is exposed to the active zone for a residence time.
- 1       9. The apparatus of claim 8, wherein the residence time is in the range of from about 0.1  
2           seconds to about 10 seconds.

- 1 10. The apparatus of claim 8, wherein the residence time is in the range of from about 0.2  
2 seconds to about 5 seconds.
- 1 11. The apparatus of claim 8, wherein the conveyor system further comprises a conveyor belt  
2 for carrying the substrate.
- 1 12. The apparatus of claim 8, wherein the conveyor system further comprises a ventilation  
2 system for evacuating the active zone adjacent to the conveyor system.
- 1 13. The apparatus of claim 1 further comprising an electro-ionization device.
- 1 14. The apparatus of claim 13, wherein the electro-ionization device is located in the active  
2 zone.
- 1 15. The apparatus of claim 13 further comprising a gas supply system for circulating said gas  
2 past said electro-ionization device.
- 1 16. The apparatus of claim 1 further comprising an infra-red radiation source, wherein the  
2 substrate is heated by exposure to said infra-red radiation.
- 1 17. The apparatus of claim 16, wherein said infra-red radiation source is located to heat the  
2 substrate prior to exposure of said substrate to said electromagnetic radiation source.
- 1 18. The apparatus of claim 1 further comprising gas injectors whereby a gas can be injected  
2 over the surface of the substrate exposed to the active zone.
- 1 19. The apparatus of claim 18, wherein the gas to be injected over the surface of the substrate  
2 exposed to the active zone comprises a gas selected from the group consisting of carbon  
3 tetrachloride, chloroform, halogen functionality compounds, oxygen functionality  
4 compounds, water vapor, oxygen, air, silanes, amine functionality compounds, ammonia,  
5 and nitrogen.
- 1 20. The apparatus of claim 1 further comprising a second electromagnetic radiation source,  
2 wherein the radiation from said second electromagnetic source comprises radiation in the

3 far ultra-violet region and wherein the radiation from said second electromagnetic source  
4 is directed to impinge on the surface of the substrate exposed to the active zone.

1 21. The apparatus of claim 1 further comprising a plurality of electromagnetic radiation  
2 sources wherein the radiation from each of said plurality of electromagnetic sources  
3 comprises radiation in the far ultra-violet region and wherein the radiation from each of  
4 said plurality of electromagnetic sources is directed to impinge on the surface of the  
5 substrate exposed to the active zone.

1 22. The apparatus of claim 1, wherein the substrate comprises a plurality of surfaces that lie  
2 in more than one plane.

1 23. The apparatus of claim 22 further comprising means for manipulating the  
2 electromagnetic radiation to control the amount of radiation that impinges on each  
3 surface.

1 24. The apparatus of claim 22, wherein the substrate comprises a first surface and a second  
2 surface that is inclined relative to the first surface.

1 25. The apparatus of claim 24, wherein the electromagnetic radiation source is moveably  
2 mounted relative to the substrate whereby in one step said electromagnetic radiation  
3 source can be moved relative to the substrate to cause the electromagnetic radiation to be  
4 incident on the first surface at an angle of about 15 degrees to about 75 degrees with  
5 respect to the normal plane of the first surface and in a second step said electromagnetic  
6 radiation source can be moved relative to the substrate to cause the electromagnetic  
7 radiation to be incident on the second surface at an angle of about 15 degrees to about 75  
8 degrees with respect to the normal plane of the second surface.

1 26. The apparatus of claim 1, wherein the substrate is comprised of a synthetic polymer.

1 27. The apparatus of claim 1, wherein the substrate is comprised of a naturally-occurring  
2 polymer.

1 28. The apparatus of claim 1, wherein said material comprises an adhesive.

1 29. The apparatus of claim 1 further comprising a treatment container for holding the  
2 substrate.

1 30. The apparatus of claim 29, wherein the treatment container further comprises a quartz  
2 window.

1 31. An apparatus for preparing a substrate, the apparatus comprising:  
2 an electromagnetic radiation source for generating an active zone, wherein said  
3 electromagnetic radiation is radiation having a wave length in the range of about 150  
4 nanometers to about 250 nanometers, and wherein the intensity of said electromagnetic  
5 radiation ranges from about 10 joules per square centimeter to about 1000 joules per  
6 square centimeter and wherein said electromagnetic radiation is directed to impinge on  
7 the substrate exposing a surface of the substrate to the active zone whereby the substrate  
8 is modified for adhering a material onto the surface of said substrate by exposure to the  
9 active zone, and  
10 wherein the apparatus operates at substantially ambient pressure.

1 32. The apparatus of claim 31, wherein said electromagnetic radiation further comprises  
2 infra-red radiation.

1 33. The apparatus of claim 31, wherein the electromagnetic radiation source is stationary.

1 34. The apparatus of claim 31, further comprising:  
2 a conveyor system for conveying the substrate through said active zone whereby the  
3 substrate is exposed to the active zone for a residence time.

1 35. The apparatus of claim 34, wherein the residence time is in the range of from about 0.1  
2 seconds to about 10 seconds.

1 36. The apparatus of claim 34, wherein the residence time is in the range of from about 0.2  
2 seconds to about 5 seconds.

1 37. The apparatus of claim 34, wherein the conveyor system further comprises a conveyor  
2 belt for carrying the substrate.

1 38. The apparatus of claim 34, wherein the conveyor system further comprises a ventilation  
2 system whereby the active zone adjacent to the conveyor system can be evacuated.

1 39. The apparatus of claim 31 further comprising an electro-ionization device.

1 40. The apparatus of claim 39, wherein the electro-ionization device is located in the active  
2 zone.

1 41. The apparatus of claim 39 further comprising a gas supply system for circulating the gas  
2 past said electro-ionization device.

1 42. The apparatus of claim 34 further comprising an infra-red radiation source, wherein the  
2 substrate is heated by exposure to said infra-red radiation.

1 43. The apparatus of claim 42, wherein said infra-red radiation source is located to heat the  
2 substrate prior to exposure of said substrate to said electromagnetic radiation source.

1 44. The apparatus of claim 31 further comprising gas injectors whereby a gas can be injected  
2 over the surface of the substrate exposed to the active zone.

1 45. The apparatus of claim 44, wherein the gas to be injected over the surface of the substrate  
2 exposed to the active zone comprises a gas selected from the group consisting of carbon  
3 tetrachloride, chloroform, chlorine functionality compounds, oxygen functionality  
4 compounds, water vapor, oxygen, air, silanes, amine functionality compounds, ammonia,  
5 and nitrogen.

1 46. The apparatus of claim 31 further comprising a second electromagnetic radiation source,  
2 wherein the radiation from said second electromagnetic source comprises radiation in the  
3 far ultra-violet region and wherein the radiation from said second electromagnetic source  
4 is directed to impinge on the surface of the substrate exposed to the active zone.

1 47. The apparatus of claim 31 further comprising a plurality of electromagnetic radiation  
2 sources wherein the radiation from each of said plurality of electromagnetic sources  
3 comprises radiation in the far ultra-violet region and wherein the radiation from each of

4 said plurality of electromagnetic sources is directed to impinge on the surface of the  
5 substrate exposed to the active zone.

1 48. The apparatus of claim 31, wherein the substrate comprises a plurality of surfaces that lie  
2 in more than one plane.

1 49. The apparatus of claim 48 further comprising means for manipulating the  
2 electromagnetic radiation to control the amount of radiation that impinges on each  
3 surface.

1 50. The apparatus of claim 48, wherein the substrate comprises a first surface and a second  
2 surface that is inclined relative to the first surface.

1 51. The apparatus of claim 50, wherein the electromagnetic radiation source is moveably  
2 mounted relative to the substrate whereby in one step said electromagnetic radiation  
3 source can be moved relative to the substrate to cause the electromagnetic radiation to be  
4 incident on the first surface at an angle of about 15 degrees to about 75 degrees with  
5 respect to the normal plane of the first surface and in a second step said electromagnetic  
6 radiation source can be moved relative to the substrate to cause the electromagnetic  
7 radiation to be incident on the second surface at an angle of about 15 degrees to about 75  
8 degrees with respect to the normal plane of the second surface.

1 52. The apparatus of claim 31, wherein the substrate is comprised of a synthetic polymer.

1 53. The apparatus of claim 48, wherein the substrate is comprised of a naturally-occurring  
2 polymer.

1 54. The apparatus of claim 48, wherein said material comprises an adhesive.

1 55. The apparatus of claim 48 further comprising a treatment container for holding the  
2 substrate.

1 56. The apparatus of claim 55, wherein the treatment container further comprises a quartz  
2 window.

1 57. An apparatus for preparing a polymer substrate for adhering a material comprising an  
2 adhesive onto said polymer substrate, wherein the apparatus operates at substantially  
3 ambient pressure, the apparatus comprising:  
4 an electromagnetic radiation source for generating an active zone, wherein said  
5 electromagnetic radiation is radiation having a wave length in the range of about 150  
6 nanometers to 250 nanometers, and wherein the intensity of said electromagnetic  
7 radiation ranges from about 10 joules per square centimeter to about 1000 joules per  
8 square centimeter and wherein said electromagnetic radiation is directed to impinge on  
9 the substrate exposing a surface of the substrate to the active zone whereby the substrate  
10 is modified for adhering a material onto the surface of said substrate by exposure to the  
11 active zone, and  
12 wherein the apparatus operates at substantially ambient pressure  
13 a conveyor system for conveying the substrate through said active zone whereby the  
14 substrate is exposed to the active zone for a residence time, wherein the residence time is  
15 in the range of from about 0.2 seconds to about 5 seconds;  
16 a ventilation system whereby the active zone adjacent to the conveyor system can be  
17 evacuated;  
18 an electro-ionization device;  
19 an air supply system for circulating air past said electro-ionization device;  
20 an infra-red radiation source; and  
21 a gas injector system whereby a gas can be injected over the surface of the substrate  
22 exposed to the active zone.

1 58. The apparatus of claim 57, wherein said infra-red radiation source is located to heat the  
2 substrate prior to exposure of said substrate to said electromagnetic radiation source.

1 59. The apparatus of claim 57, wherein the gas to be injected over the surface of the substrate  
2 exposed to the active zone comprises a gas selected from the group consisting of carbon  
3 tetrachloride, chloroform, halogen functionality compounds, oxygen functionality  
4 compounds, water vapor, oxygen, air, silanes, amine functionality compounds, ammonia,  
5 and nitrogen.

1 60. The apparatus of claim 57, further comprising a second electromagnetic radiation source,  
2 wherein the radiation from said second electromagnetic source comprises radiation in the  
3 far ultra-violet region and wherein the radiation from said second electromagnetic source  
4 is directed to impinge on the surface of the substrate exposed to the active zone.

1 61. The apparatus of claim 57, further comprising a plurality of electromagnetic radiation  
2 sources wherein the radiation from each of said plurality of electromagnetic sources  
3 comprises radiation in the far ultra-violet region and wherein the radiation from each of  
4 said plurality of electromagnetic sources is directed to impinge on the surface of the  
5 substrate exposed to the active zone.

1 62. The apparatus of claim 57, wherein the substrate comprises a plurality of surfaces that lie  
2 in more than one plane.

1 63. The apparatus of claim 62 further comprising means for manipulating the  
2 electromagnetic radiation source to control the amount of radiation that impinges on each  
3 surface.

1 64. The apparatus of claim 62, wherein the substrate comprises a first surface and a second  
2 surface that is inclined relative to the first surface.

1 65. The apparatus of claim 64, wherein the electromagnetic radiation source is moveably  
2 mounted relative to the substrate whereby in one step said electromagnetic radiation  
3 source can be moved relative to the substrate to cause the electromagnetic radiation to be  
4 incident on the first surface at an angle of about 15 degrees to about 75 degrees with  
5 respect to the normal plane of the first surface and in a second step said electromagnetic  
6 radiation source can be moved relative to the substrate to cause the electromagnetic  
7 radiation to be incident on the second surface at an angle of about 15 degrees to about 75  
8 degrees with respect to the normal plane of the second surface.

1 66. The apparatus of claim 57, wherein the substrate is comprised of a synthetic polymer.

1 67. The apparatus of claim 57, wherein the substrate is comprised of a naturally-occurring  
2 polymer.



3 68. An apparatus for fabricating a shoe having at least one sole, the apparatus comprising:  
4 an electromagnetic radiation source for generating an active zone, wherein said  
5 electromagnetic radiation comprises radiation in the far ultra-violet region and wherein  
6 said electromagnetic radiation is directed to impinge on the sole exposing a surface of the  
7 sole to the active zone whereby the sole is modified for adhering a material onto the  
8 surface of said sole, and  
9 wherein the apparatus operates at substantially ambient pressure.

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1 69. The apparatus of claim 68, wherein said electromagnetic radiation further comprises  
2 infra-red radiation.

1 70. The apparatus of claim 68, wherein of said electromagnetic radiation comprises radiation  
2 having a wave length in the range of about 150 nanometers to 300 nanometers.

1 71. The apparatus of claim 68, wherein of said electromagnetic radiation comprises radiation  
2 having a wave length in the range of about 150 nanometers to 250 nanometers.

1 72. The apparatus of claim 68, wherein the intensity of said electromagnetic radiation ranges  
2 from about 2.0 joules per square centimeter to about 5,000 joules per square centimeter.

1 73. The apparatus of claim 68, wherein the intensity of said electromagnetic radiation ranges  
2 from about 10 joules per square centimeter to about 1000 joules per square centimeter.

1 74. The apparatus of claim 68, wherein the electromagnetic radiation source is stationary.

1 75. The apparatus of claim 68, further comprising:  
2 a conveyor system for conveying the substrate through said active zone whereby the  
3 substrate is exposed to the active zone for a residence time.

1 76. The apparatus of claim 75, wherein the residence time is in the range of from about 0.1  
2 seconds to about 10 seconds.

1 77. The apparatus of claim 75, wherein the residence time is in the range of from about 0.2  
2 seconds to about 5 seconds.

1 78. The apparatus of claim 75, wherein the conveyor system further comprises a conveyor  
2 belt for carrying the sole.

1 79. The apparatus of claim 75, wherein the conveyor system further comprises a ventilation  
2 system for evacuating the active zone adjacent to the conveyor system.

1 80. The apparatus of claim 68 further comprising an electro-ionization device.

1 81. The apparatus of claim 80, wherein the electro-ionization device is located in the active  
2 zone.

1 82. The apparatus of claim 80 further comprising an air supply system for circulating air past  
2 said electro-ionization device.

1 83. The apparatus of claim 68 further comprising an infra-red radiation source, wherein the  
2 sole is heated by exposure to said infra-red radiation.

1 84. The apparatus of claim 83, wherein said infra-red radiation source is located to heat the  
2 sole prior to exposure of said sole to said electromagnetic radiation source.

1 85. The apparatus of claim 68 further comprising gas injectors whereby a gas can be injected  
2 over the surface of the sole exposed to the active zone.

1 86. The apparatus of claim 85, wherein the gas to be injected over the surface of the sole  
2 exposed to the active zone comprises a gas selected from the group consisting of carbon  
3 tetrachloride, chloroform, halogen functionality compounds, oxygen functionality  
4 compounds, water vapor, oxygen, air, silanes, amine functionality compounds, ammonia,  
5 and nitrogen.

1 87. The apparatus of claim 68 further comprising a second electromagnetic radiation source,  
2 wherein the radiation from said second electromagnetic source comprises radiation in the  
3 far ultra-violet region and wherein the radiation from said second electromagnetic source  
4 is directed to impinge on the surface of the sole exposed to the active zone.

1 88. The apparatus of claim 68 further comprising a plurality of electromagnetic radiation  
2 sources wherein the radiation from each of said plurality of electromagnetic sources  
3 comprises radiation in the far ultra-violet region and wherein the radiation from each of  
4 said plurality of electromagnetic sources is directed to impinge on the surface of the sole  
5 exposed to the active zone.

1 89. The apparatus of claim 68, wherein the sole is comprised of a synthetic polymer.

1 90. The apparatus of claim 68, wherein the sole is comprised of a naturally-occurring  
2 polymer.

1 91. The apparatus of claim 68, wherein said material comprises an adhesive.

1 92. A method for preparing a substrate, the method comprising:  
2 generating an active zone using an electromagnetic radiation source; and  
3 exposing said substrate to the active zone whereby the substrate is modified for adhering  
4 a material comprising an adhesive onto said substrate by exposure to the active zone, and  
5 wherein the method is performed at substantially ambient pressure.

1 93. The method of claim 92, wherein the substrate comprises a polymer.

1 94. The method of claim 92, wherein said substrate comprises a sole of a shoe.

1 95. The method of claim 92, wherein said substrate comprises a composite used in aircraft  
2 and space vehicle fabrication.

1 96. The method of claim 92, wherein said substrate comprises a component used in  
2 automobile manufacturing.

1 97. The method of claim 92, wherein said substrate comprises a well-plate, wherein said  
2 well-plate is used for biochemical analysis.

1 98. The method of claim 92, wherein said electromagnetic radiation further comprises infra-  
2 red radiation.

1 99. The method of claim 92, wherein of said electromagnetic radiation comprises radiation  
2 having a wave length in the range of about 150 nanometers to 300 nanometers.

1 100. The method of claim 92, wherein of said electromagnetic radiation comprises  
2 radiation having a wave length in the range of about 150 nanometers to 250 nanometers.

1 101. The method of claim 92, wherein the intensity of said electromagnetic radiation  
2 ranges from about 2.0 joules per square centimeter to about 5,000 joules per square  
3 centimeter.

1 102. The method of claim 92, wherein the intensity of said electromagnetic radiation  
2 ranges from about 10 joules per square centimeter to about 1000 joules per square  
3 centimeter.

1 103. The method of claim 92, further comprising:  
2 conveying the substrate through said active zone using a conveyor system whereby the  
3 substrate is exposed to the active zone for a residence time.

1 104. The method of claim 103, wherein the residence time is in the range of from about  
2 0.1 seconds to about 10 seconds.

1 105. The method of claim 103, wherein the residence time is in the range of from about  
2 0.2 seconds to about 5 seconds.

1 106. The method of claim 103, wherein the conveyor system further comprises a  
2 conveyor belt for carrying the substrate.

1 107. The method of claim 103, further comprising:  
2 evacuating the active zone adjacent to the conveyor system.

1 108. The method of claim 92 further comprising:  
2 exposing the substrate to a discharge from an electro-ionization device.

1 109. The method of claim 108, wherein the electro-ionization device is located in the  
2 active zone.

1 110. The method of claim 108 further comprising:  
2 circulating a gas past said electro-ionization device so that said gas flows over the  
3 electro-ionization device onto the substrate.

1 111. The method of claim 103 further comprising:  
2 exposing the substrate to an infra-red radiation source, wherein the substrate is heated by  
3 exposure to said infra-red radiation.

1 112. The method of claim 111, wherein the step of exposing the substrate to said infra-  
2 red radiation source is performed prior to the step of exposing said substrate to the active  
3 zone.

1 113. The method of claim 92, further comprising:  
2 injecting a gas over the surface of the substrate exposed to the active zone.

1 114. The method of claim 113, wherein the gas to be injected over the surface of the  
2 substrate exposed to the active zone comprises a gas selected from the group consisting  
3 of carbon tetrachloride, chloroform, halogen functionality compounds, oxygen  
4 functionality compounds, water vapor, oxygen, air, silanes, amine functionality  
5 compounds, ammonia, and nitrogen.

1 115. A method for preparing a polymer substrate, the method comprising:  
2 generating an active zone at substantially atmospheric pressure using an electromagnetic  
3 radiation source, wherein said electromagnetic radiation is radiation having a wave length  
4 in the range of about 150 nanometers to 250 nanometers, and wherein the intensity of  
5 said electromagnetic radiation ranges from about 10 joules per square centimeter to about  
6 1000 joules per square centimeter whereby the polymer substrate is modified for adhering  
7 a material comprising an adhesive onto said polymer substrate by exposure to said active  
8 zone;  
9 conveying the substrate through said active zone whereby the substrate is exposed to the  
10 active zone for a residence time, wherein the residence time is in the range of from about  
11 0.2 seconds to about 5 seconds;  
12 evacuating the active zone adjacent to the conveyor system;

13 exposing the surface to an electro-ionization device;  
14 circulating a first gas stream past said electro-ionization device so that the first gas stream  
15 flows past the electro-ionization device and onto the surface;  
16 exposing the surface to an infra-red radiation source; and  
17 injecting a second gas stream over the surface of the substrate.

1 116. The method of claim 115, wherein the step of exposing the substrate to said infra-  
2 red radiation source is performed prior to the step of exposing said substrate to the active  
3 zone.

1 117. The method of claim 115, wherein the gas of the first gas stream to be injected  
2 over the surface of the substrate exposed to the active zone comprises a gas selected from  
3 the group consisting of carbon tetrachloride, chloroform, halogen functionality  
4 compounds, oxygen functionality compounds, water vapor, oxygen, air, silanes, amine  
5 functionality compounds, ammonia, and nitrogen.

1 118. The method of claim 115, wherein the gas of the second gas stream to be injected  
2 over the surface of the substrate exposed to the active zone comprises a gas selected from  
3 the group consisting of carbon tetrachloride, chloroform, halogen functionality  
4 compounds, oxygen functionality compounds, water vapor, oxygen, air, silanes, amine  
5 functionality compounds, ammonia, and nitrogen.

1 119. The method of claim 115, wherein the substrate is comprised of a synthetic  
2 polymer.

1 120. The method of claim 115, wherein the substrate is comprised of a naturally-  
2 occurring polymer.

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